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1964 JUL 23

Director, Electronics and Control Division (Code RET)
Office of Advanced Research and Technology
National Aeronautics and Space Administration
Washington, D. C.

OTS PRICE

XEROX $ 1.00 FS

MICROFILM $ .50 MF

Attention: Mr. Roland Chase

Reference: Contract NASw 888

Subject: Development of Macroscopic Optical Waveguide Components - Progress 1964 May-June.

Gentlemen:

This is the fourth progress report on the development of macroscopic waveguide components for optical systems being performed for the National Aeronautics and Space Administration (NASA) by Wheeler Laboratories (WL) under contract NASw 888. This report covers the months of May and June 1964. The overall objectives of the current contract, to be completed by 1964 NOV 28 as described in Ref. 1, are: (1) to determine the factors affecting the design and fabrication of macroscopic waveguide and waveguide components, (2) to investigate specific configurations in order to develop practical concepts for component design, and (3) to undertake actual component fabrication and testing to prove the feasibility of the design concepts.

Work Performed During Current Month.

The initial phase of this program, was completed 1964 MAY 28, and involved the following tasks: (1) an analysis of propagation in dielectric waveguides, (2) a survey and study of material and fabrication techniques required for construction of optical components, (3) experimental testing of the waveguides considered suitable for component fabrication. The work of the initial phase is described in the following interim report: Report 1209, "A Macroscopic Waveguide Medium for Laser System Components", 1964 JUN 10. The second phase of the program which was initiated

in June involves: (1) a study and performance analysis of component configurations, (2) design, fabrication and testing of certain components.

A. Analysis of Waveguide and Waveguide Components.

An analysis of a metal-bisected waveguide, which includes the effects of the finite conductivity of the metal, has shown that propagation is fundamentally different than with a perfectly conducting metal. The results of this study are presented in the interim report, Ref. 5; the significant result is that, contrary to what was previously believed, propagation is identical for both polarizations (TM and TE modes).

A waveguide directional coupler consisting of two parallel dielectric slab waveguides has been analyzed. For 3 db (half-power) coupling, a coupling region of 0.67" is required with a waveguide separation of 1/3 core width.

A brief investigation of waveguide bends has been made. A minimum radius of curvature of about 30 inches is obtained for a typical waveguide.

The possibility of constructing an optical modulator within the waveguide medium, by utilizing the electro-optic effect, is being studied.

B. Survey and Study of Waveguide Construction.

As reported previously, the study of waveguide construction has been divided into three parts: (1) configurations, (2) fabrication techniques, and (3) materials. During this period, several new materials have been purchased as possible waveguide media. These include: (1) Corning Microsheet glass slabs for use as solid-core, liquid-cladding waveguide, (2) two ground and polished 5 inch long glass slabs (with one mirrored surface) for testing of longer waveguides of both the ordinary and bisected-slab configuration and (3) General Electric fused quartz rod and tubing for testing of waveguides of circular configuration.

A study of various techniques for construction of an all solid waveguide has been initiated. Such processes as chemical diffusion and leaching appear promising.

C. Experimental Testing.

During the initial phase of this program, the experimental testing was directed toward a correlation of the experimental propagation characteristics of macroscopic optical waveguides with the theoretical calculations. In general, sufficiently close agreement has been obtained to confirm the method of operation. Further testing of waveguides is directed toward routine tests of the suitability of various materials and configurations as waveguide media for

component fabrication. In order to facilitate these tests a pattern range has been implemented which can automatically record aperture field and radiation patterns.

A bisected slab waveguide has been experimentally evaluated. This configuration is capable of propagating as a single mode guide; however, the characteristics of both polarizations are identical because of the finite conductivity of the metal (aluminum) wall, as mentioned earlier.

Tests of a solid-core, liquid-cladding slab waveguide composed of microsheet glass core with chlorobenzene cladding have indicated that the homogeneity of this glass is not sufficient for operation as a single mode waveguide. Purchase of slabs of better quality glass is planned.

Tests of circular waveguides made of quartz rod and tubing have been partially successful. The quartz tubing is filled with a liquid (Cineole) which closely matches the index of refraction of the quartz and thus forms a liquid core waveguide. Single mode operation of the tubing is possible; however the configuration is not considered adaptable to component design. Results of tests of the quartz rod, liquid cladding waveguide indicate a variation in index of refraction of the quartz which produces a natural guiding of the wave, without cladding. However, the wave appears to be bound too tightly to the center of the rod to permit use as a coupler.

The 5" long glass plates obtained during this period are being used to experimentally evaluate a component which has been called a spatially coherent detector (Ref. 3). This device, which consists of a length of optical waveguide in front of a photomultiplier, will be used to measure radiation patterns with greater accuracy than with a photomultiplier alone.

D. Conferences.

A conference has been planned with R. Chase and other NASA personnel to review progress on this contract, and is tentatively scheduled for August. An agenda for this meeting was prepared and has been sent to NASA.

Work Planned for Next Month.

During the month of July, it is planned to continue the experimental evaluation of different types of waveguides and the design and performance analysis of certain components.

(1) Quartz slabs are being purchased and will be tested as solid-core, liquid cladding waveguides.

(2) The experimental evaluation of the spatially coherent detector will be continued.

(3) Various techniques for fabrication of completely solid waveguides and waveguide components will be investigated. Consultation with outside personnel in the field of chemistry and glass fabrication is planned.

(4) An analysis of optical modulators and laser oscillators, fabricated within the waveguide medium, is planned.

Personnel.

The work on this project has been carried on by E. R. Schineller, D. W. Wilmot and H. M. Heinemann under the direct supervision of H. W. Redlien. Advice and general direction has been provided by H. A. Wheeler and F. H. Williams.

References.

(1) D. W. Wilmot, R. A. Kaplan, "Development of Macroscopic Waveguide and Waveguide Components for Optical Systems", Wheeler Labs. Report 1139; April 1, 1963.

(2) E. R. Schineller, "Development of Macroscopic Optical Waveguide Components - Progress 1964 February, Technical Letter No. 1 to NASA; 1964 March 17.

(3) H. W. Redlien, "Development of Macroscopic Optical Waveguide Components - Progress 1964 March", Technical Letter No. 2 to NASA; 1964 April 15.

(4) H. W. Redlien, "Development of Macroscopic Optical Waveguide Components - Progress 1964 April, Technical Letter No. 3 to NASA; 1964 May 19.

(5) E. R. Schineller, D. W. Wilmot and H. M. Heinemann, "A Macroscopic Waveguide Medium for Laser System Components", Wheeler Laboratories Report 1209; June 10, 1964.

Very truly yours,

E. Ronald Schineller

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Assistant Project Supervisor

cc: Roland Chase (24 + 1T)
New Technology Representative Code (ATU) (1)